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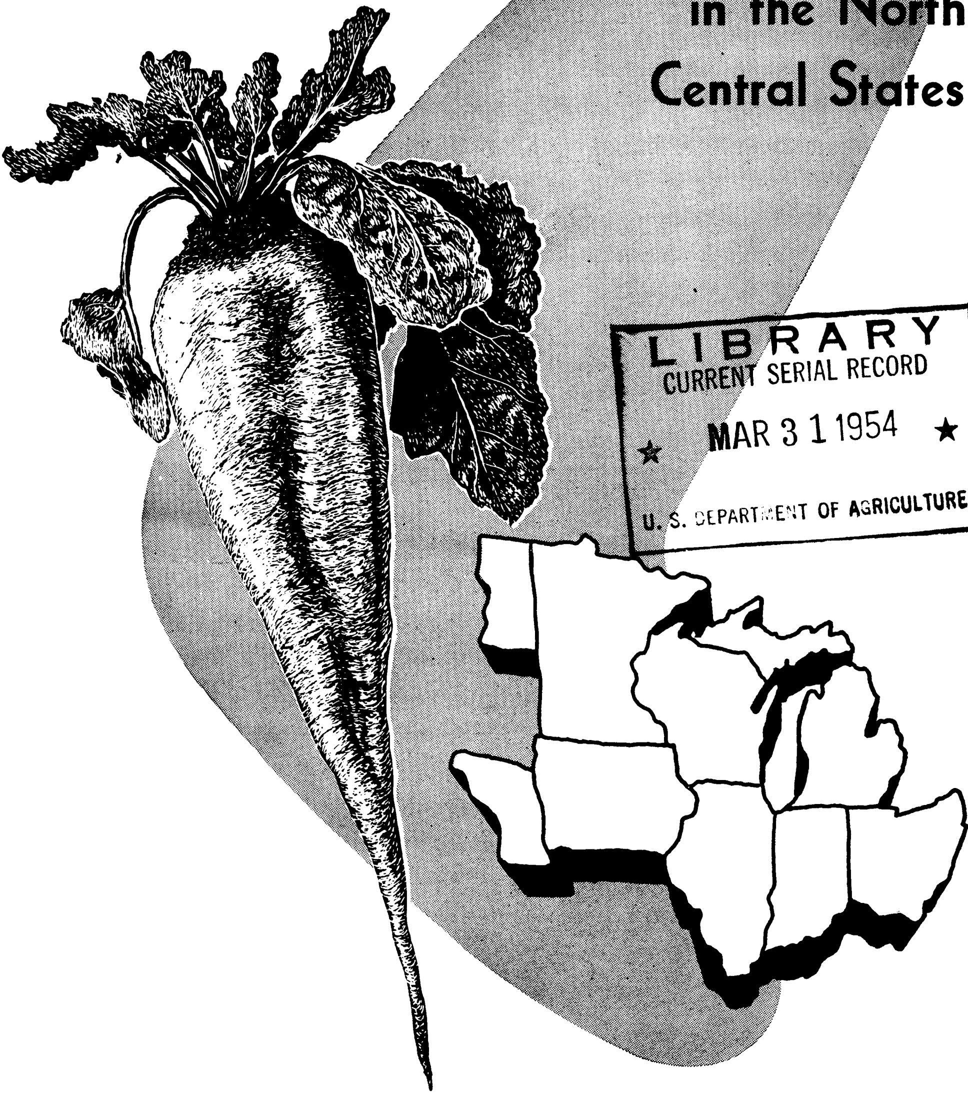
SUGAR BEET CULTURE

in the North Central States



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CONTENTS

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SUGAR BEET CULTURE IN THE NORTH CENTRAL STATES[1]

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Sucrose, the sugar of commerce and kitchen, is extracted from the tissues of the sugar beet and the sugarcane. Whichever plant it comes from, the product, when pure, is identical in all properties and for all purposes.

The sugar beet is a biennial plant that is cultivated for the sugar it stores in the root. In comparison with other plants, the quantity stored is high, frequently exceeding 20 percent of the root weight. The sugar is formed in the leaves from water and carbon dioxide in the presence of chlorophyll (the green coloring matter of the leaves), sunlight supplying the energy for this chemical process. The greater part of the sugar made by the leaves may be used by the plant during its period of rapid growth, but when vegetative growth is slowed in late season a large part of the sugar is stored and the roots become of high quality. The commercial crop is harvested at or near the end of the period of the first year's growth when the roots have reached a relatively large size and contain the maximum amount of sugar.

Sugar-Beet-Producing Areas in the United States

Sugar beets in the United States are successfully grown in four fairly distinct areas that differ from each other by climatic or cultural conditions: (1) The humid area located in the North Central States; (2) the Great Plains area; (3) the Mountain States area; and (4) the Pacific coast area.

In the humid area where the crop is grown almost entirely under natural precipitation, sugar-beet-growing districts have been developed in Michigan, Ohio, Indiana, Wisconsin, Minnesota, Iowa, Illinois, eastern North Dakota, and eastern Nebraska. The production of sugar beets is not general over this whole area but is restricted to districts where soil and other conditions are favorable. Of the average annual harvested acreage for the United States, more than one-fourth has been in the humid area.

Unlike other important field crops, the sugar beet crop is always grown under contract with a beet-sugar factory (fig. 1), since sufficient acreage must be planted to beets to produce the tonnage necessary for factory operation. Acceptance of the contracts by the company is delayed until such acreage has been signed up. Thus the sugar beet contracts, entered into yearly

[1] Many of the photographs were obtained from the Farmers and Manufacturers Beet Sugar Association and from the E. E. Patton collection through the courtesy of Mrs. Emily Patton Colmus.

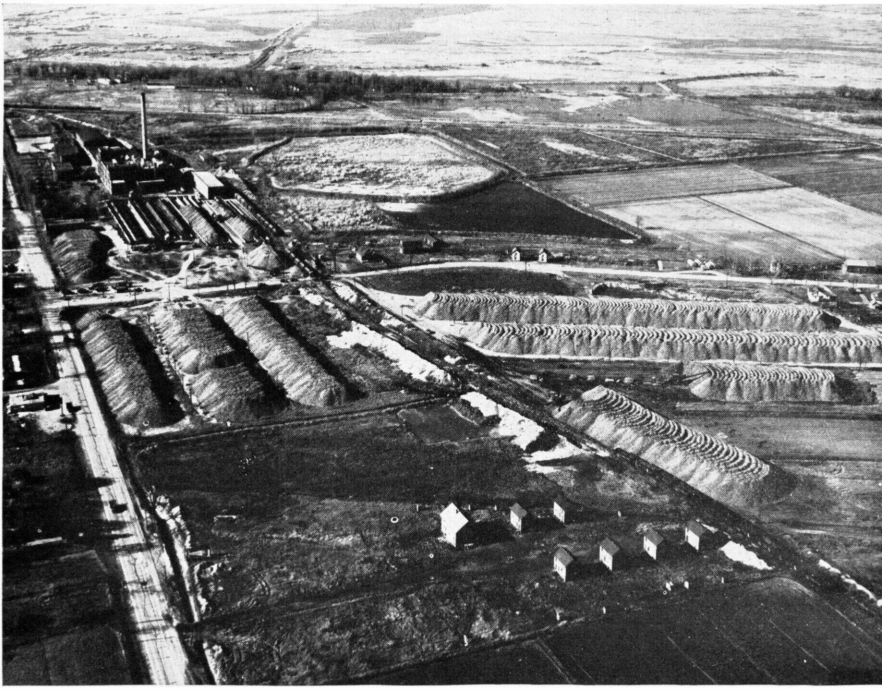

FIGURE 1.—Beet-sugar factory, showing storage piles with pile-ventilating equipment installed in some piles.

by the growers, carry stipulations as to the acreage to be grown, the seed to be used, planting, culture, harvest, and crop delivery. The factory supplies the seed at a stipulated price and will accept the crop grown if it meets certain minimum conditions or quality requirements when delivered. In the humid area it has seldom, if ever, been necessary to refuse beets on account of low quality.

The contracts under which the beet crop is grown in the humid area at the present time are of the participating type under which the proceeds from the sale of sugar, pulp, and molasses are divided between the processor and the growers upon some percentage basis, as, for example, 50–50. The growers' portion of the returns is subdivided among the individual growers according to the tonnage each has delivered. Under such contracts, the grower's obligation is to produce the beets and deliver them to the factory, and the factory's obligation is to process the beets and market the sugar, pulp, and molasses.

Climatic Adaptation

For successful production in the humid area, the sugar beet crop requires plentiful and well distributed moisture during the growing season. The quantity of water required for continuous growth bears a very definite relationship to the amount of foliage that has developed, more and more being required as the foliage increases in size. As the season becomes warmer the demand for water also increases. In the humid area nearly half of the total annual precipitation normally comes dur-

ing the growing season, May to September, inclusive.

Although the precipitation during the early part of the growing season is probably more than is actually required by the crop, the quantity received during August and September is not likely to exceed what the crop can use. During the latter part of the growing season when the precipitation received may not be sufficient to meet the demands of the foliage and when the crop has drawn heavily upon the moisture reserves in the soil, there is usually a decrease in the amount of foliage present. Some farmers supplement rainfall by irrigation (fig. 2).

In addition to the adequate supply of moisture, the sugar beet crop is favored by a long and moderately cool growing season. Nearly all of the beet-sugar factories operating in the humid area are located in areas with a mean summer temperature (May to September, inclusive) of 67° to 72° F., as shown in figure 3. Although it is possible to grow the sugar beet outside this zone in the humid area, its culture has not proved promising. Warm days and fairly cool nights during the growing season combine to favor the rapid growth of the crop. In the latter part of the season, progressively cooler nights, the exhaustion of available nitrogen, and the decreasing moisture supply slow up vegetative growth and accelerate sugar storage.

Soil Requirements

In the humid area, sugar beets are grown upon both the mineral soils, derived from decomposed rock, and the organic-type, or muck, soils. Although the greater part of the sugar beet acreage is upon mineral-type soils, the acreage upon muck soil is considerable. While these soil types differ radically in their physical properties, both should have good depth, adequate drainage, be well aerated, and should not be strongly acid. In addition to these qualities, the mineral

FIGURE 2.—Irrigation of beets in the humid area by means of a sprinkler system.

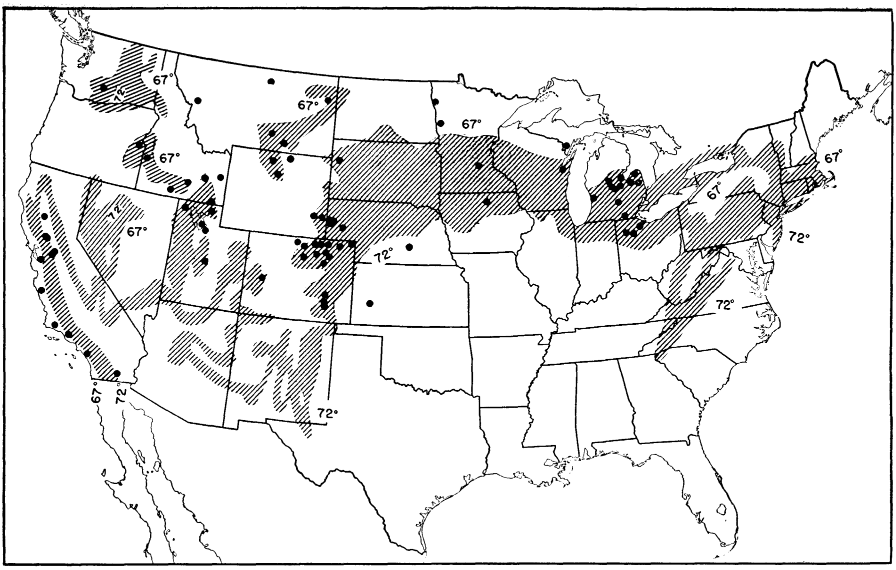

FIGURE 3.—Beet-sugar factories in the United States. The shaded portion shows the zone having a mean summer temperature of 67° to 72° F.

soil types should also have high organic content and high moisture-holding capacity.

Experience with the mineral soil types has shown that those that combine the necessary characteristics to make them adaptable for successful sugar beet production are usually the dark-colored, heavier types, such as loams, silt loams, clay loams, and clays as represented by the Toledo-Vergennes (Brookston-Toledo), the Miami-Kewaunee (Conover), and the Miami-Crosby-Brookston soil-type associations, although satisfactory yields have often been obtained upon lighter textured mineral soils.

The organic soils, or mucks, are characterized by their extremely high organic content and moisture-holding capacity. Many of these soils have been found to be unsuited for the growing of sugar beets, whereas others give very satisfactory root yields, although the quality of the crop may not be so high as that obtained with the mineral soil types.

Normally the sugar beet sends its taproot deep into the soil (fig. 4), and soil structure or other conditions that limit depth of root penetration decrease the volume of soil upon which the taproot and its numerous small feeding roots may draw for the mineral elements and moisture used in growth. Practically all soils upon which high yields are regularly produced have a depth of at least 3 feet before there is any change in the physical characteristics that prevent the penetration of roots. On the other hand, if the depth of root penetration is limited by repellent soil structures, by a high water table, or by poor soil aeration, the roots harvested are apt to be short and ill-shaped (fig. 6). If the soil has sufficient depth, the roots harvested will be long and tapering (fig. 5). Although it is sometimes possible to obtain a fair tonnage from a field where soil structures or drainage conditions prevent beets from mak-

FIGURE 4.—The sugar beet sends its taproot deep into the soil.

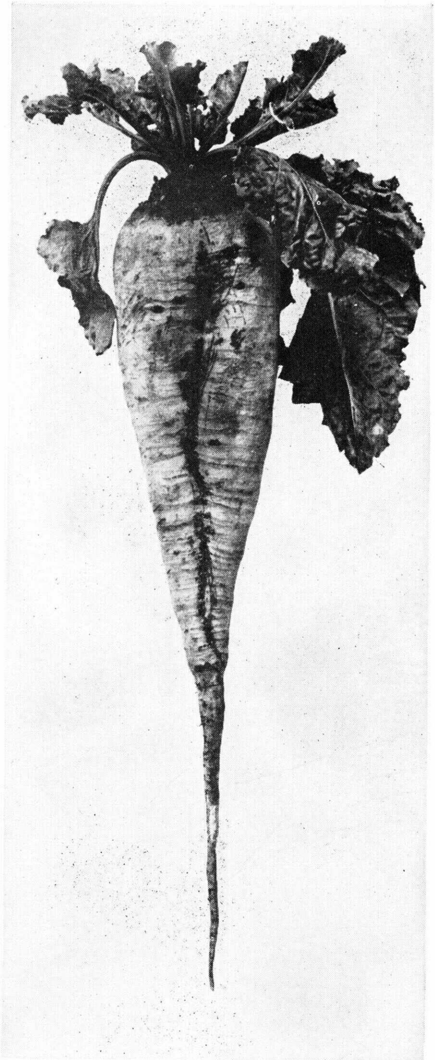

FIGURE 5.—A sugar beet of desirable shape.

ing their normal growth of well-formed roots, tare and tailings loss at the factory is increased with such roots.

In the humid area far greater loss is brought about by lack of adequate surface and tile drainage than is commonly supposed. Provision must be made to permit the water resulting from heavy rains to be carried off from the beetfields into drainage ditches or catch basins with a minimum of opportunity for soil erosion. The accumulation of surface water when no escape channels are provided often results in serious crop damage. Lack of tile drainage (fig. 7) permits the water that has penetrated the soil to remain there, limiting the aeration of the soil and the depth to which the beet roots can penetrate, and thus limiting the volume of soil upon which the crop can draw for its mineral and moisture supply.

The sugar beet is productive on either slightly acid or alkaline soils in the humid area, the crop being grown upon soils testing as low as pH 5.8 to 6.0 (acid) and as high as pH 7.5 or more (alkaline). For the best results it is generally considered that the soil should be only slightly acid to neutral in reaction. If good stands of alfalfa and clover can be obtained upon a field, the reaction is favorable for the sugar beet crop.

Although the beet crop can withstand drought as well as or better than most other cultivated crops, if the amount of moisture held within the soil is insufficient during a drought period so that growth lags, then the yield is correspondingly reduced. It is during these periods that the heavier types of mineral soils and the organic soils, with their higher moisture-holding capacities, have a great advantage over the lighter soil types (fig. 8). Sandy areas in a field, as well as areas with a sandy subsoil, are often clearly outlined during the heat of the day by the wilting of all the beet foliage within such areas, whereas the foliage of the plants on the adjacent darker and heavier soil shows no lack of moisture.

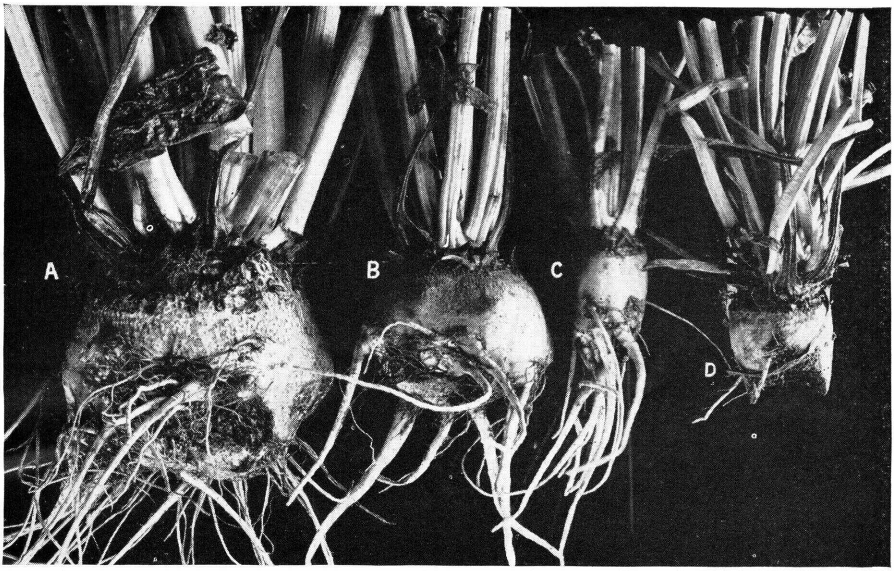

FIGURE 6.—Sugar beets of undesirable shape, caused by a high water table.

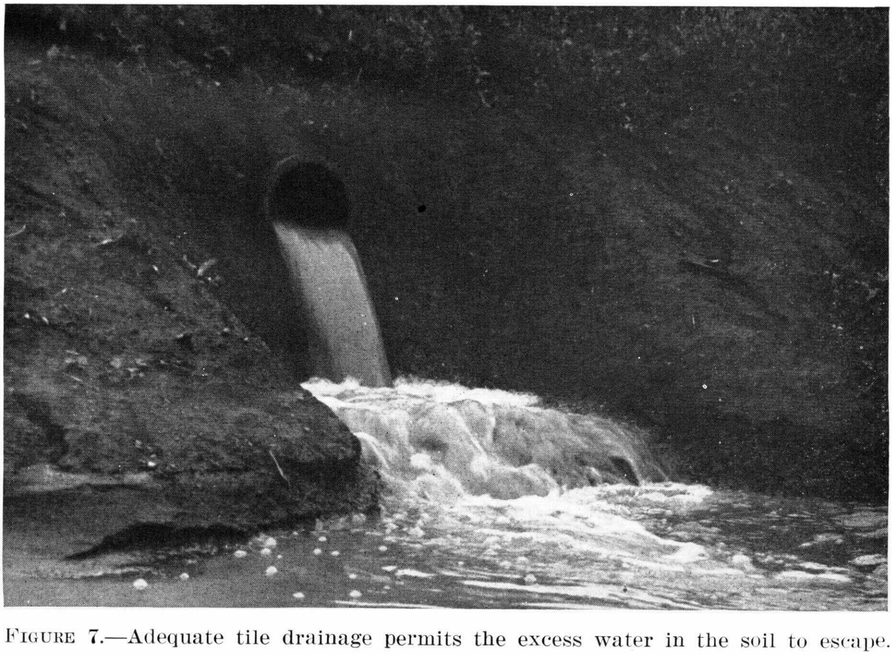

FIGURE 7.—Adequate tile drainage permits the excess water in the soil to escape.

FIGURE 8.—Contrasting growth of sugar beets on darker and heavier mineral soil (foreground) and on lighter mineral soil (center and background).

Rotations

In the production of the sugar beet crop in the humid area, the rotations followed are quite different for the mineral-type and the organic-type soils.

For the mineral-type soils, a properly designed rotation (1) provides for the addition of nitrogen either from soil-building crops or as manure or fertilizer used with cash crops; (2) maintains humus and rebuilds the tilth of the soil; (3) permits more effective use of labor in land preparation, especially through the economical utilization of the condition of the soil as left by the preceding crop; (4) decreases the cost of production by reducing demands for labor; (5) gives ample opportunity to attain and maintain an essentially weed-free condition; and (6) allows the beet crop to avoid, to a very considerable extent, insect pests and plant diseases that may attack the crop. For the organic soils, the principal advantages of crop rotation are (1) the elimination or avoidance of plant diseases; (2) the most effective utilization of the phosphorus and potassium fertilizers that have been applied to such soil; and (3) the control of weeds.

For a mineral soil, the properly planned rotation for sugar beets will include one or more legumes, sod, or mixed legume-and-sod crops that will add organic matter to the soil. If leguminous crops are used alone or are included in a mixture, the double purpose of adding organic matter and nitrogen to the

soil is accomplished. Of the soil-building legumes, alfalfa, sweetclover, and the clovers, when plowed under, are most effective. Bromegrass is becoming very popular for use in legume-grass mixtures, as the fine fibrous roots of the grass have a very beneficial effect upon the tilth of the soil in bringing about a desirable crumb soil structure.

On the mineral soils in the humid area the sugar beet crop should be grown as the first or second crop in the rotation following the turning under of the green-manure crop. Although higher yields are quite commonly obtained when the sugar beets are grown immediately following the green-manure crop, not all growers follow this practice, many of them preferring to plant sugar beets as the second crop following the soil-building crop. If sugar beets are grown immediately following the turning under of the green-manure crop the maximum benefit may not be obtained, since the organic matter turned under may not have had time in which to decay. The decay of organic matter may be hastened by applying chemical nitrogen to the green-manure crop just before it is turned under. The use of an intertilled crop between the green-manure crop and the sugar beets in the rotation gives ample time for the decomposition of the organic matter to improve the tilth of the soil and makes possible effective control of any weeds that may have obtained a foothold during the year or years in which the field was in the soil-building crop.

The occurrence of seedling diseases (black root or damping-off) seems definitely to be increased if the sugar beets are planted shortly after the spring plowing of alfalfa, sweetclover, or red clover crops. Loss from such diseases is reduced if corn, beans, soybeans, or possibly some other cultivated crop is grown following the green-manure crop and preceding sugar beets in the rotation. The adverse effects on stand that come from growing the sugar beet crop as the first crop following the turning under of alfalfa or other leguminous crop in the spring can be avoided by turning under the legume crop in late August or early September of the previous year. High yields are being obtained on the mineral soils by the growers who have adopted this practice.

On mineral soils, grassy alfalfa or clovers that have occupied a field for 3 or more years may be found to be infested with cutworms, white grubs, and in the lower, wetter places with wireworms. Late summer or early fall plowing will reduce the injury by such pests to the following sugar beet crop. If early fall plowing cannot be done, an intervening cultivated crop less subject to insect injury may be grown. Two intervening cultivated crops may be necessary to eliminate injury from wireworms if the soil is heavily infested.

The sequence of crops within a properly planned rotation for either mineral or organic soils should be such as to leave the soil, prior to the planting of the beet crop, as free from weeds as possible. This feature of the sequence deserves special consideration, for successful mechanization of the spring work—the reduction of or even the elimination of hand work—which has been so greatly advanced by the use of processed seed, depends definitely upon the elimination of weeds.

A well-planned rotation gives ample time between the removal of one crop and the planting of the next for proper preparation of the soil. It has been demonstrated repeatedly that higher yields of sugar beets are obtained from fall-plowed mineral soils as compared with the

yields obtained from such soils when spring plowed (fig. 9). A cropping system that allows the removal of the preceding crop early enough to permit early fall plowing of the mineral soils for the next year's sugar beet crop is strongly recommended for the humid area.

On organic soils, or mucks, the properly planned rotation for sugar beets will include such crops as are not subject to the same diseases or attacks by the same insects as the sugar beets. Such rotations should also permit ample opportunity for weed elimination.

FIGURE 9.—Effect of the date of plowing of mineral soil upon the growth of sugar beets: Left, beets on fall-plowed soil; right, on spring-plowed soil.

Tillage

In the preparation of the soil for the sugar beet crop, all work should be performed in such manner as will minimize losses caused by either wind or water erosion. Plowed soil should offer no channels for rapid runoff, although offering full opportunity for excess rainfall or snow water to drain away from the field. If the soil is sloping, contour working or terracing is recommended. The surface soil should at all times be protected from erosion to the greatest practicable extent. Fall plowing should be done sufficiently early so that oats or some other crop that winterkills can be planted. Before being winterkilled, such a crop will make sufficient growth so that the roots will bind the soil together and the tops will cover and protect the surface without interfering with the spring work in the preparation of the seedbed.

The sugar beet crop requires adequate and timely attention to the preparation of the seedbed if full and satisfactory stands are to be attained and proper root development facilitated. The seedling is small, the seed or germ being slightly larger in size than a clover seed, and, as with other small-seeded crops, the soil in the seedbed should be fine and firm for proper germination of the seed and emergence of the seedlings. The sugar beet has a taproot that penetrates deeply within the soil. For proper development of this root the seedbed

should be deeper than for other crops.

Farm operators, having intimate knowledge of the soil being worked and the effect of the various tillage implements upon it, should so schedule the various operations that the surface soil may be reduced with a minimum of operations to a deep, relatively fine, firm, but not compacted, seedbed by planting time. The time of year when the soil should be plowed, the depth of plowing, and the number of subsequent workings required to produce a seedbed of the desired characteristics depend to a very large extent upon the type and condition of the soil.

With tractor equipment, early fall plowing to a depth of 8 or 10 inches is generally practicable on the heavier types of mineral soil (fig. 10). Even though a cover crop such as oats may be planted on the fall-plowed soil, the field should

FIGURE 10.—Plowing with tractor equipment.

be left as rough as possible since freezing and thawing during the fall, winter, and early spring assist materially in breaking up and mellowing the large lumps of earth that were turned up, thereby reducing the amount of work required in the preparation of the seedbed. Were plowing to the same depth to be attempted in the spring when the soil is usually wet, preparation of a seedbed of proper fineness and depth would be very difficult and possibility of unduly compacting the soil would be much greater.

When the sugar beet crop follows the navy bean crop in the rotation, a considerable number of the growers do not plow the soil either in the fall or in the spring but prepare it for the sugar beet crop by disking thoroughly shortly before planting and finishing the preparation of the seedbed with a spike-tooth harrow. In some districts this method has met with considerable success.

A once-over method of soil preparation for the sugar beet crop has been tried on a relatively large scale, and the results obtained have been sufficiently favorable for it to be advocated to some extent by certain agencies. In this method the soil is spring plowed. Attached to the plow at the time of plowing and pulled by the same tractor is a device for fining, smoothing, and compacting the soil (harrow, cultipacker, or combination of cultipacker and spring-tooth harrow) that completes the preparation of the seedbed in one operation. Following such preparation of the soil the sugar beets are planted without delay. This preparation may be advantageous with some of the lighter types of mineral soil or with soils deficient in organic matter which if fall-plowed would be found following the action of frost during the winter to be nearly as compact in the spring as they were before the fall plowing.

The methods used to prepare the muck, or organic, soils for the sugar beet crop differ radically from the methods followed on mineral soils. Very often the organic soils are so loose that all tillage operations are pointed toward compacting the soil (fig. 11). Even if it is deemed necessary to plow the muck soil, more work is necessary to firm such a soil than is ordinarily necessary even on the loosest type of mineral soil. The muck soil often becomes so dry and loose that the sugar beet seedlings may be severely damaged or killed by the surface soil blowing away. Prevention of such damage is difficult, but the damage suffered is generally less where the soil has

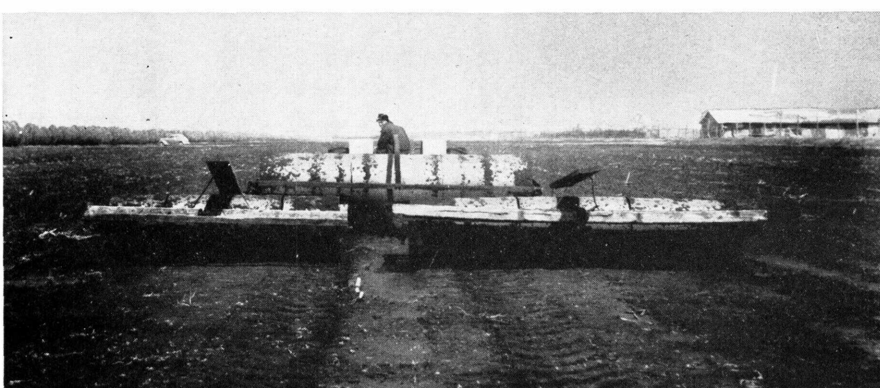

FIGURE 11.—Rolling muck soil to compact it.

been properly firmed, the crop rows planted at right angles to the wind exposure, and the surface left as irregular as possible.

In the humid area the soil is usually worked to a point where one final set of operations will complete the preparation of the seedbed, and the seed is then planted immediately. Combination implements (fig. 12) followed by an automatic land leveler (fig. 13) are being

FIGURE 12.—Combination implements are used in the final preparation of the seedbed.

FIGURE 13.—The automatic land leveler not only crushes clods but also firms the soil.

used more and more in the final preparation of the seedbed. The soil preparation implements are immediately followed by the drills and the seed is planted almost as rapidly as the soil is prepared. The advantage of this plan is that, if the work is interrupted by rain, the seed has already been planted on the part of the field that has been finished and the work performed is not lost. Danger of compaction of the soil through repeated operations is also eliminated.

With the progressive mechanization of the sugar beet crop, the automatic land leveler is replacing the cultipacker or clodcrusher. The automatic land leveler not only crushes clods but also firms the soil in a desirable manner while leveling it, so as to facilitate precision planting (fig. 14) and mechanical stand reduction.

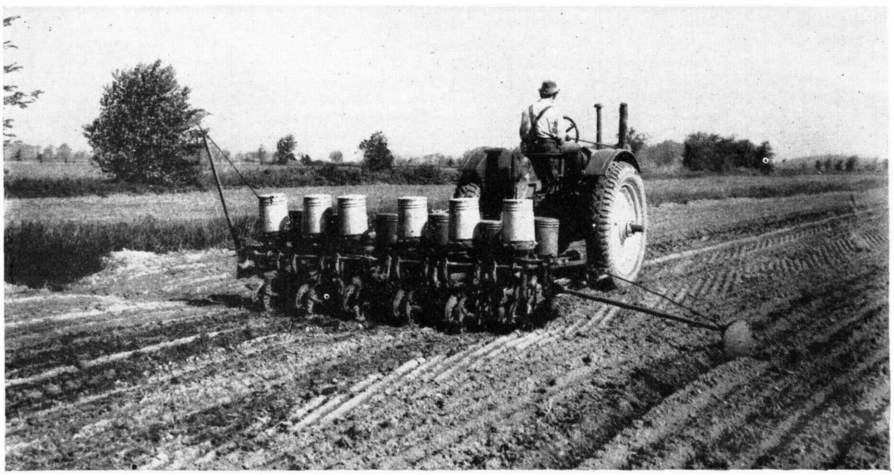

FIGURE 14.—Multiple-row precision drills drop the seed pieces so that the seedlings stand singly or at some slight interval from the next.

Plant Food Removed

As with other nonleguminous crops, the sugar beet is classed as soil-depleting. The opinion, however, that the sugar beet crop is hard upon the soil and that its culture decreases the soil fertility more rapidly than is the case with other nonconserving crops is unwarranted. Chemical analyses showing the quantity of plant nutrients removed from the soil by an average crop of sugar beets and by comparable yields of wheat, corn, oats, tomatoes, and potatoes, as well as by the legumes, alfalfa and soybeans, do not furnish any basis for stigmatizing the sugar beet as a "soil robber." No matter what crop is grown, it must not be expected that the soil can continue to produce good crops indefinitely without the use of fertilizers to maintain a proper fertility balance and to replace plant nutrients which have been removed. In the humid area it should be the general practice to apply fertilizers for the production of all crops, whether sugar beets are grown or not.

Fertilization of Sugar Beets

The sugar beet crop responds definitely to fertilization, and in the humid area where sugar beets are included in the rotation a large part of the fertilizer used during the rotation is applied to or for the sugar beet crop.

Barnyard manure, although not in itself a balanced fertilizing material, is an excellent fertilizer for sugar beets. Sugar beet growing and livestock or dairy farming go hand-in-hand, as the beet tops make excellent livestock forage and the cattle supply manure for the sugar beet crop. Not only does the manure application increase the organic content and moisture-holding capacity and improve the tilth of mineral soils, but it also supplies some nitrogen and some of the mineral elements the plants use. On organic soils the application of barnyard manure often promotes desirable bacterial activity within the soil, thereby increasing productiveness.

In some very successful rotations on mineral soils some growers make heavy applications of barnyard manure for sugar beets in place of turning under green-manure crops. Other growers spread the barnyard manure on the green-manure crop before turning it under, thus hastening the decay in the soil of the organic material.

In the humid area commercial fertilizer is almost always used with the sugar beet crop (fig. 15). The amount used varies greatly, but experience has shown that heavy applications are profitable. Some growers get excellent returns from applying 1,000 pounds per acre, or more, of a well-balanced commercial fertilizer.

Commercial fertilizer mixtures that give the best results vary with the soil and the farming system followed. Muck soils usually give the best yields when the mixture contains a high proportion of potash, whereas the mineral soils usually require a greater proportion of phosphoric acid. The lighter mineral soils are more often found to be deficient in nitrogen and potash than the heavier, darker types, but for both types of mineral soils

FIGURE 15.—The four center rows received no fertilizer, whereas the fertilizer was applied to the field on the right and left.

a higher proportion of phosphoric acid than either nitrogen or potash is usually necessary.

The more liberally the mineral soil has been fertilized with barnyard manure, green-manure crops, and legume sods, the less will be the need for applying nitrogen and potash in fertilizer form. Where little manure and no green-manure crops have been used and where legume sods have not been broken regularly, it will be found necessary to apply larger amounts of nitrogen and potash in proportion to the phosphoric acid in the mixture to obtain comparable results.

Fertilizer Placement

The manner in which the fertilizer is applied to the soil and its placement with respect to the seed have appreciable effects upon the yields of sugar beets. Formerly when applications were from 125 to 250 pounds per acre, the fertilizer was allowed to fall in the seed furrow with the seed at the time of planting. Later, as heavier and heavier applications came into use, such placement of the fertilizer often interfered with germination of the seed, especially if the moisture supply was scanty, and the fertilizer sometimes injured the seedlings. Studies and experience have indicated that the most efficient placement of the fertilizer is in a band close to and slightly below the seed. Most of the beet drills now on the market are equipped with devices to accomplish this even with the heavier applications. But many of the growers still prefer to drill part of the application deep into the soil during seedbed preparation and place the rest in a band close to the seed when it is planted. When the application is split in this manner, the mixture applied during soil preparation usually does not contain any nitrogen.

Side Dressing

Supplemental applications of nitrogen may be made to the crop as a side dressing either before or following blocking and thinning. The rate recommended is 40 pounds of elemental nitrogen per acre. The crop responds more quickly to the nitrate forms than to the ammonia. Experimental work and experience in commercial fields indicate that the earlier applications are more effective than the later ones; that if alfalfa or other leguminous crop has been turned under within a year or two of the beet crop, the response from the nitrogen applications may not be so pronounced; and that applications made as late as when the crop is laid by may depress the sucrose content somewhat and reduce sugar recovery.

The dry forms of nitrogenous fertilizer used for side dressing may be applied either with fertilizer attachments of a beet drill so offset (fig. 16) that the furrowers of the drill do not run upon the beet rows, or by means of special attachments (fig. 17) placed on the beet cultivator. The liquid forms may be applied with weed sprayers, either as a spray on the surface of the soil or with special equipment on the beet cultivator to place the liquid in the soil.

When the crop is sidedressed with dry fertilizer, the material is usually placed as near the row and as deep as possible without causing extensive root pruning, although good results have been obtained when it has been drilled in between alternate rows.

Although side dressing of sugar beets with fertilizer is not as yet general, the results that have been obtained indicate that it may become a desirable operation if soil-building crops and manures are not used regularly and especially if the sugar beet crop lags in growth or the foliage shows lack of nitrogen.

FIGURE 16.—Applying fertilizer as a side dressing with an offset beet drill.

FIGURE 17.—Applying fertilizer as a side dressing with special attachments on the cultivator.

Minor Elements

With the continued cultivation of the soil and the removal of the crops grown, some of the mineral elements that the plants use in relatively small quantities may become deficient. Definite indications of boron and manganese deficiencies have been found in sugar beet fields on mineral soil in the humid area. Muck soils may be deficient in certain minor elements in the virgin state. Copper sulfate, when applied to some muck soils, and magnesium, when applied to some muck and some mineral soils under certain conditions, have had beneficial

effects upon the crop, thus indicating deficiency in these elements.

Boron deficiency is ordinarily found in Michigan on the lighter, more gravelly types of mineral soils and in Wisconsin on the heavier soils, such as those at the bottoms of swales. The lack of boron is indicated by the cessation of top growth and the blackening and blighting of the inner, unfolding beet leaves; transverse ladderlike marks appear on the groove of the leaf petioles; and the flesh of the beet root becomes discolored. Affected plants may lose their tops and small accessory buds may start feebly, making the sugar beet plant look as though it had been injured by trampling. The leaf symptoms commonly show up late in July and in August and seem to be correlated with dry soil conditions. Manganese deficiency is indicated by an unhealthy, light yellow-green color of the foliage and usually by a very definite retardation in the rate of growth.

Minor-element deficiencies may be corrected by the application of small amounts of the minor element needed. Boron deficiency may usually be corrected by the application of as little as 5 to 10 pounds of borax per acre. If the soil has a strong binding action on boron or is alkaline, it may be necessary to apply as much as 50 pounds per acre. Care must be exercised not to apply boron in an excessive amount, because some crops, such as corn and potatoes, are sensitive to this chemical element. Manganese deficiency may also be corrected by applying from 10 to 50 pounds of manganese sulfate per acre (fig. 18). If copper applications are found to have beneficial effects when applied to muck soils, the recommended rate is 50 pounds of copper sulfate per acre. Where magnesium is needed, either on the muck or mineral soils, this element may be supplied through the application of several hundred pounds of dolomitic limestone per acre, the amount applied being limited only by the change caused in the pH value of the soil.

The use of minor elements in the humid area has become so common that mixed fertilizers containing the desired percentage of any particular minor element or elements, except possibly magnesium, may now be purchased from many of the companies engaged in the manufacture of fertilizers.

FIGURE 18.—The rows on the right and left of the four center rows received an application of manganese sulfate.

Soil Amendments

Soil amendments are materials that are applied to the soil to improve its structure or to produce other effects whereby the crops are better able to utilize the plant nutrients of the soil.

Under continuous cultivation and partially as the result of the application of commercial fertilizers, soils in the humid area tend to become acid. The application of lime, as finely ground limestone, hydrated lime, or factory waste lime (fig. 19), to correct the acidity of the soil is the most common of all soil amendment treatments. Although calcium, derived from the lime, is necessary in plant growth and considerable amounts are removed by certain crops, soils are limed primarily to correct soil acidity, and the amount of lime applied should be determined by the change in soil reaction desired. Care should be exercised to avoid excess applications of lime because phosphate, as well as the minor elements, boron and manganese, become less available if the soil is made strongly alkaline. If the soil needs lime, the common practice is to apply the lime to the soil for the alfalfa or clover crop included in the rotation, the sugar beets and other crops in the rotation benefiting in turn from the application.

FIGURE 19.—Spreading factory waste lime on the soil.

The practice of applying common salt to the soil prior to growing a crop of sugar beets is common in some districts in the humid area. The benefits derived from the application of common salt to muck soils have resulted in general recommendations being made for its use at the rate of 500 pounds or more per acre. Recommendation is not made for the use of salt on mineral soils, although in a few beet-growing districts beneficial effects apparently have been obtained. No deleterious effect upon mineral soil structure or adverse effect upon the crops that follow the sugar beets have been shown. Common salt, however, must be considered as a soil amendment, and its use should be restricted to those soils and those sections in which definite benefit is derived by the sugar beet crop. When common salt is used it is ordinarily applied to the soil with a lime spreader shortly before the crop is planted and worked into the soil during the seedbed preparation.

Machinery and Labor Requirements

In comparison with other field crops in the humid area, sugar beets in the past have been an expensive crop to grow, requiring much hand labor. Progressive mechanization of the operations in crop production

has already reduced the amount of hand labor required and gives promise of still greater reduction.

Farm management studies made at the Michigan State Agricultural Experiment Station show that the total number of hours of labor required to produce an acre of sugar beets in the humid area decreased from 125 (75 hand and 50 machine) in 1915 to 99 (70 hand and 29 machine) in 1935. In 1946 the number of hours of labor required per acre had further declined to 71, of which 60 hours were hand labor, chiefly required for blocking, thinning, pulling, and topping the beets. At the present time, with 80 percent or more of the crop being harvested mechanically and with machine work being in considerable part substituted for hand blocking and thinning, the number of hours of hand labor is much less.

The general use of the tractor and processed seed has brought about some decisive changes in sugar beet machinery. Low-capacity implements are being replaced by gang plows, combination implements for seedbed preparation, multiple-row and precision drills, multiple-row cultivators, stand-reducing implements, and mechanical harvesters.

Processed seed, which term includes sheared, decorticated, and seed stocks graded to fairly small size, is now planted with precision drills. The seed pieces are dropped about an inch apart (fig. 20). The sugar beet plants arising from such seedlings stand either singly or not more than 2 or 3 at a place. The sparse distribution of seedlings along the row and the absence of clumps of plants make it practicable to use stand-reducing machines. These are replacing hand labor once necessary for blocking and thinning. Beginning with 1946, mechanical harvesters have made a very decided reduction in the amount of hand labor required in harvesting the crop. It is possible that within a few years the only hand labor needed will be for hoeing the beets following mechanical stand reduction.

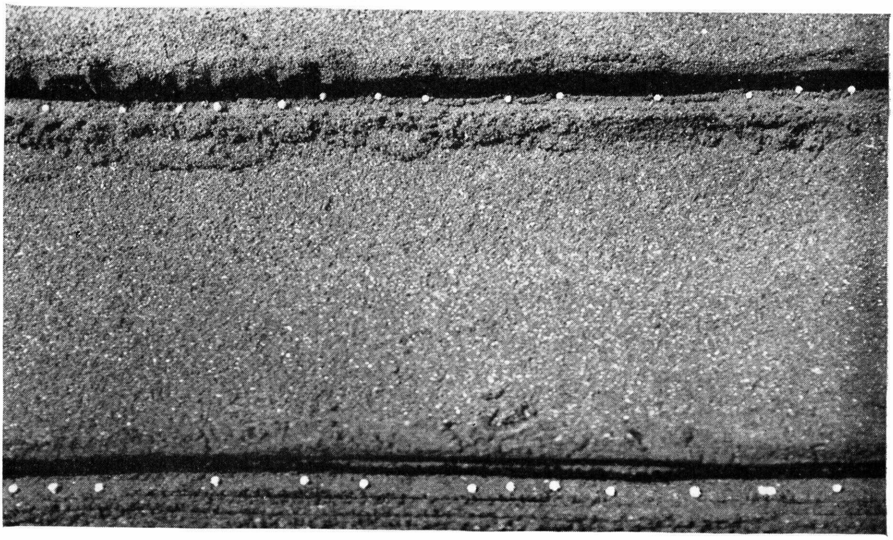

FIGURE 20.—Processed seed as dropped in the seed furrow by a precision drill. The seed has been coated with a white dust, to contrast with the soil.

Weed Control

Within the past few years chemical aids to agriculture in the form of herbicides have been developed. When properly used, these may aid greatly in eliminating the weed problem from the sugar beet fields in the humid area. Thus, 2,4–D may be used at some place in the rotation for the elimination of bindweed and other perennial broad-leaved weeds from the field. Several different compounds have been developed for ridding fields of perennial grasses.

Preemergence Treatment.—Annual weeds and grasses often may be practically eliminated or at least greatly reduced by spraying the entire soil surface with compounds or mixtures of compounds shortly before the beet seedlings appear. At the present time, the most promising results in the humid area are being obtained with mixtures of PCP (pentachlorophenol) at the rate of 8 pounds per acre and either TCA (trichloracetate) or IPC (isopropylphenylcarbamate) at the rate of 4 to 5 pounds per acre, the PCP controlling the seedlings of the annual broad-leaved weeds and the TCA or IPC controlling the grass seedlings.

Postemergence Treatment.—Common salt is also sometimes used as a herbicide after the sugar beet plants are up. Spraying is usually done when 4 to 6 leaves have developed. The sugar beet has greater tolerance for salt than many broad-leaved weeds and certain of the grasses, and it is therefore possible to spray the beets with a strong salt solution (fig. 21). Two pounds of salt to a gallon of water are applied at the rate of 100 to 300 gallons of the strong brine per acre. The spray is applied in as narrow a band as possible directly upon the rows. If the weeds and grasses are very small, the strong salt solution will kill them without serious injury being done to the sugar beets.

The entire field of preemergence and postemergence control of weeds by chemicals is in the developmental stage. New compounds are being continually investigated. The grower should consult with his county agricultural agent or the fieldman of the beet-sugar company for latest developments.

Figure 21.—Spraying sugar beet seedlings with a saturated solution of common salt.

FIGURE 22.—Sugar beet seed as it appears on the plant.

Sugar Beet Seed

The sugar beet seed, as it matures on the plant (fig. 22) and is harvested, is not a seed like a pea or bean, but is a seed ball often containing two or more true seeds (fig. 23). The sugar beet flowers grow singly or in clusters of 2 to 7 or more, the flower parts being fused at the base. At maturity they dry to form the seed ball.

The sugar beet seed planted in the humid area at the present time is produced in the United States. The varieties used are those that are resistant to leaf spot, or blight, and capable of giving good yields of high quality roots under conditions of severe leaf spot exposure.

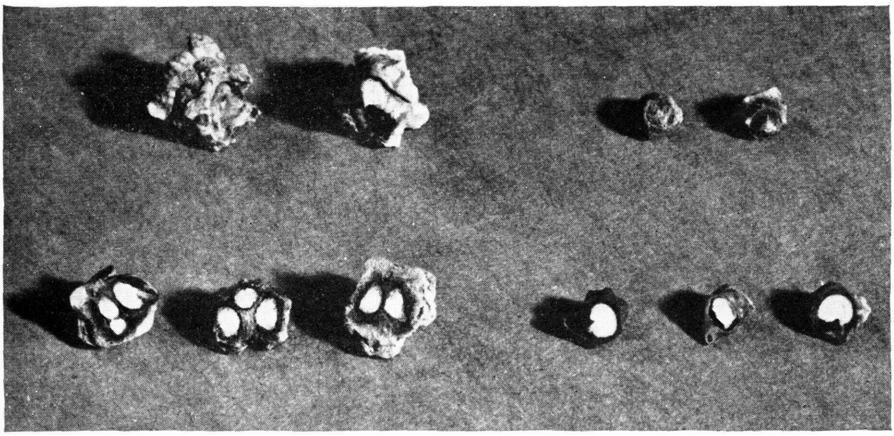

FIGURE 23.—Sugar beet seed before (upper row) and after (lower row) processing. Note the size of the seed ball and the number of seeds held within the ball.

Time of Planting

For the best development, the sugar beet plant needs a long growing season. Although the planting period in the humid area extends from the middle of April to the last of May, higher yields are obtained from the earlier plantings. In the humid area late March and April conditions are often cold and wet and for that reason seedbeds can usually be prepared more quickly and the planting done earlier on fall-plowed than on spring-plowed soil. The higher yields obtained from the earlier plantings represent not only the differences attributable to a longer period for growth but also greater production and storage of food reserves late in the season that come from the larger plant units.

Depth of Planting

Many failures in obtaining a satisfactory stand of sugar beets in the humid area have been blamed upon improper planting depth when some other condition, as a poorly prepared seedbed, is primarily responsible. Experiments indicate that, considering the size of the germ, or seed, there is a considerable range in the depth to which the seed pieces may be planted without materially affecting the emergence of the seedlings. Nevertheless, planting depths of

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more than $1\frac{1}{2}$ inches are not recommended.

In the humid area the soil is usually quite moist in the spring and warms slowly, so the early plantings should be comparatively shallow—one-fourth to three-fourths of an inch. As the season advances and the soil becomes warmer and the surface drier, the planting depth may be greater, but it is usually inadvisable to place the processed seed more than 1 to $1\frac{1}{4}$ inches below the surface. With all depths of planting, the soil below and above the seed pieces should be firm enough to give good contact between the seed piece and the moist soil and thus insure the rapid transfer of moisture from the soil to the seed piece.

In the latter part of the planting season, dashing rains often occur that cause crusting of the soil. When such crusts form before the emergence of the seedlings, appropriate operations should be undertaken to break the crust in order that the seedlings, which are very small, may be able to emerge.

Row Width

The sugar beet crop is always grown in rows to permit intertilling. During the time when all machine work was performed by horse-drawn equipment and hand labor was plentiful, the beets were planted in relatively narrow rows, sometimes as close as 18 inches but generally 20 to 22 inches apart. With the progressive mechanization of the crop the row width has become progressively greater, until at the present time most of the sugar beet crop in the humid area is grown in rows 24, 26, 28, or more inches apart. Obviously, wide rows mean fewer trips across the field with the sugar beet harvester. A compelling reason for wider rows for sugar beets is that these widths are used with other intertilled crops in the rotation. If the sugar beets have the same row width as used with the bean crop, for example, the tractor-drawn cultivator can be used on the two crops without adjustment of tools.

Increase in row width is associated with some loss in efficiency of use of field space, and this may be reflected in somewhat lower crop yields as compared with the yields obtainable from narrower rows. The trend toward wide rows, therefore, reflects a compromise in which the grower is willing to accept a lower yield in return for greater ease in use of mechanical equipment.

Quantity of Seed Planted

The quantity of seed to plant per acre for the best results depends upon climatic and soil conditions, upon the weed problem, and upon the row width. When whole seed was used and the rows were relatively narrow and the blocking and thinning performed by hand, the amount recommended was from 12 to 15 pounds per acre. With processed seed and the relatively wider rows and much of the spring work performed mechanically, the recommended rate varies from 4 to 6 pounds per acre, depending to some extent upon the condition of the seedbed and the anticipated weed infestation, more seed being recommended under the adverse conditions. Under favorable soil conditions it is believed that 10 to 12 seed pieces, each piece containing a viable germ, per foot of row will result in the emergence of sufficient seedlings for successful mechanical stand reduction.

Blocking and Thinning, or Stand Reduction

The introduction and use of processed seed, together with the great increase in the mechanization of the spring work, have brought about great changes in the manner in which the work in the early part of the season is performed, although it is probable that some part of the beet acreage in the humid area will still be cared for by hand.

As explained previously, the true seed of the sugar beet is small, the seedling relatively weak, and emergence usually imperfect. An excess of seed, either whole or processed, is planted to assure sufficient seedlings to give the desired permanent stand. The initial stand obtained is usually thicker than the permanent stand desired, and it is necessary to remove the excess seedlings either by hand or machine before competition sets in and hinders the crop.

Formerly, when unprocessed seed was used, the blocking and thinning were performed almost entirely by hand (fig. 24), although efforts were made at various times and in various ways to reduce the hand labor of the operations (fig. 25). Since the use of processed seed has become general, several types of

FIGURE 24.—Hand blocking and thinning of sugar beets.

FIGURE 25.—One of the earlier machines developed for stand reduction.

stand-reducing machines have been developed that promise to eliminate practically all hand labor connected with blocking and thinning the beets (fig. 26), although some hand labor may still be necessary for hoeing.

For mechanical stand reduction to be a complete success, the initial stand of seedlings must be sufficiently thick to undergo the several operations performed with the stand-reducing machines. These remove surplus plants and eliminate weeds and grasses in the row. A final stand of seedlings averaging, if possible, 100 to 150 per 100 feet of row should be left.

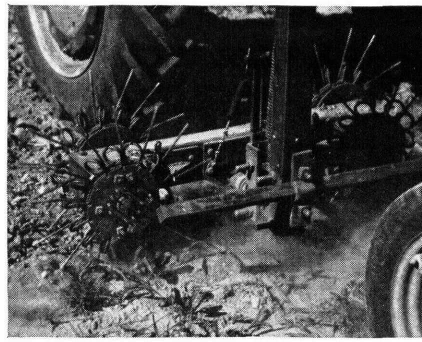

FIGURE 26.—Stand-reducing and weeding mechanism devised by Department of Agriculture engineers. Two counter-rotating spring-tined heads remove surplus sugar beet plants and the weeds from each sugar beet drill-row.

Time of Stand Reduction

Formerly when stand reduction of the sugar beets was accomplished entirely by hand through blocking and thinning and the entire operation was normally accomplished at one time, effort was made to have the work done when the beets were in the 4- to 6-leaf stage. Earlier thinning, although giving good results, was not regarded as practicable on account of the small size of the seedlings, and later thinning, when the plants were larger and interplant competition had set in (fig. 27), did not give as good results. In order to have the hand blocking and thinning done as soon as the beets reached the proper size, the beet-sugar-company field supervisors strove to have the plantings in their districts staggered so that not too many acres of beets would reach the thinning stage at the same time. Even on farms where large

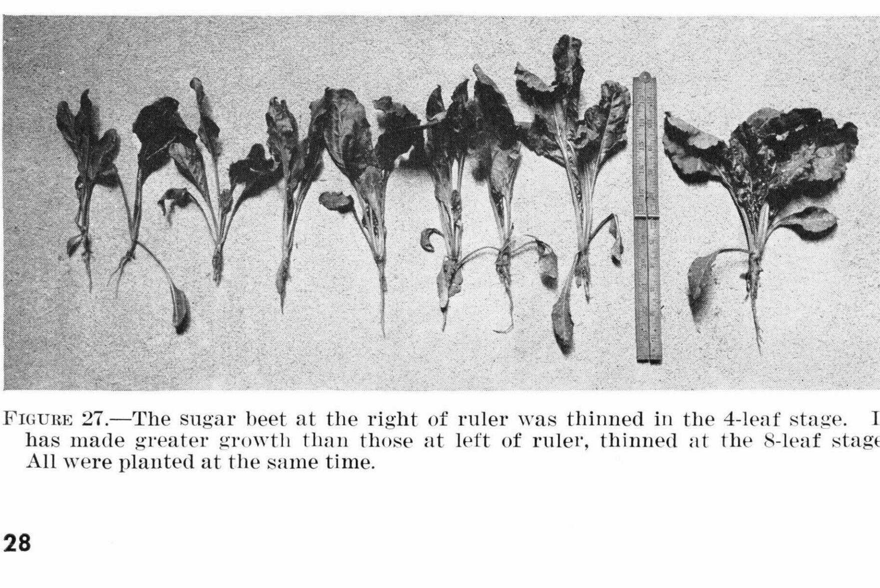

FIGURE 27.—The sugar beet at the right of ruler was thinned in the 4-leaf stage. It has made greater growth than those at left of ruler, thinned at the 8-leaf stage. All were planted at the same time.

acreages were grown, only 6 to 10 acres would be planted at a time—all because of the importance of blocking and thinning the beets at the proper stage of growth.

Now that processed seed, precision drills, herbicides, and mechanical stand reducers are being used, the picture has changed completely. No longer is it necessary to stagger the plantings in districts or on farms; all acreage may be planted as early as possible, for the mechanical stand reducers have freed the beet grower from the necessity of waiting until hand labor is available. Neither is it so necessary to have blocking and thinning of sugar beets performed at a definite stage of plant growth, for with the processed seed and the precision drill many of the plants stand singly or, less frequently, as doubles or triples, so that serious interplant competition does not set in so early as was the case when 12 to 15 pounds of unprocessed seed were planted per acre.

Mechanical stand reduction has also changed the picture in another way. Previously, the stage of plant growth was of prime importance and the operations of blocking and thinning were performed either by one laborer as one operation or by two laborers—one to block and the other to thin the seedlings. With the mechanical stand reducers the job may begin when the plants are quite small, and it is entirely practicable to accomplish the desired stand reduction by stages—by 2, 3, or even 4 different trips of the machine down the rows, these being spread over a considerable period of time. It is possible for the grower to observe the results from each operation. Weeds in the row are eliminated by the mechanical thinner as well as many of the weaker beet plants, until the plant population has been reduced to the desired number per 100 feet of row.

The down-the-row mechanical stand reducers with the interchangeable tool heads have met with greater favor among the sugar beet growers in the humid area than the earlier methods of cultivation across the rows, although the latter method will probably continue to be used in some districts either alone or in combination with down-the-row machines.

The down-the-row machines have toolheads equipped with 1/4-inch round-spring steel finger weeders. Toolheads equipped with blocking knives that cut out definite portions of the beet row also can be attached to replace the weeders. The toolhead selected for use depends upon the initial stand of seedlings, the size of the sugar beet plants, and the weeds present. It is common practice to go over the field first while the beets are still relatively small with the stand reducer equipped with the finger weeder toolheads. This operation must be done very carefully, as in the earlier stages of plant growth it is very easy to remove the small beet plants. Later, as the beets become more firmly attached to the soil and the stand can be more easily seen, the blocking-knife toolhead may be used. For the first time over with the blocking-knife toolhead, the knives may cut out 50 percent of the beet row in 3- to 4-inch blocks, leaving undisturbed blocks of approximately the same size. For the second time over with the blocking-knife toolhead, the wheel used has more but shorter knives and is used upon the row in the opposite direction from the first blocking operation. This operation also cuts out approximately 50 percent of the seedlings remaining in the row but operates to divide or cut off the ends of the blocks left by the first time over with the blocking knives.

Spacing the Plants

When unprocessed seed was used and the seedlings were blocked and thinned by hand, it was possible to specify to some extent the spacing pattern of the plants. This often resulted in a definite uniformity or regularity of the plants in the beetfield. With processed seed and the reduction in stand being accomplished at random by mechanical means, the spacing of the plants that remain is very irregular. At least 100 to 150 plants per 100 feet of row should remain after stand-reduction operations and these should be spread along the row as uniformly as possible. The occurrence of 2 or 3 plants very close together in 1 place has very little influence upon the final acre yield if there are not more than 20 to 30 percent of such hills.

Cultivation

Cultivation soon after the seedlings have emerged from the soil is usually desirable for the purpose of stirring to speed the drying of the surface soil as well as to destroy weed seedlings. This cultivation is accomplished in the conventional manner by using knives or disks on a 4- to 6-row cultivator, set to cut as close to the row as possible. If the stand-reduction operations are to be accomplished by hand labor, the row of beet seedlings will be left standing on a low, narrow ridge of soil by this operation, but if stand-reducing machines are to be used, the loose soil is moved back to support and protect the narrow ridge during the stand-reducing operations.

Following blocking and thinning or stand reduction by machine, when the plants remaining have become erect, it is customary to cultivate the beets again, and during this operation to shift soil back into the row so that grass and weed seedlings which may have started are covered. When this operation is carefully performed, the weed population of the field is greatly reduced.

The number of cultivations during the rest of the season is determined by the number of rains received and the weeds that start following the rains. During each of the later cultivations the weeds between the rows are cut off and soil is pushed into the row to cover such weeds as may have started. As the season advances and the root systems become more extensive, cultivation should be very shallow to avoid injury to the feeding roots. Cultivation should be discontinued when the foliage is sufficiently large to be injured by the machines.

Harvest

Sugar beet harvest in the humid area is ordinarily deferred as long as possible, to permit the crop to make the greatest possible growth. Harvest generally starts late in September or early in October and is carried forward rapidly in order that the job may be finished before the soil freezes. Mechanical harvesting and immediate truck delivery have not only very definitely reduced the amount of hand labor involved but have shortened the time required to harvest the crop and deliver it to the factory. Formerly, when the beets were lifted by horse-drawn machines and pulled and topped by hand (fig. 28), the amount of labor available determined the rate of

harvest. At the present time when the greater part of the acreage is harvested mechanically, the rate of harvest is determined by the number of machines operating. Some of the machines (fig. 29) place the

FIGURE 28.—When sugar beets were topped by hand, a large amount of labor was necessary in the harvest of the crop.

FIGURE 29.—Sugar beet harvester. With this type, the sugar beets are lifted, topped, and deposited in a windrow.

harvested beets in piles or windrows from which they are later loaded into trucks by mechanical loaders. Other types of machines load the beets directly into the trucks or into carts from which they are loaded into the trucks (fig. 30).

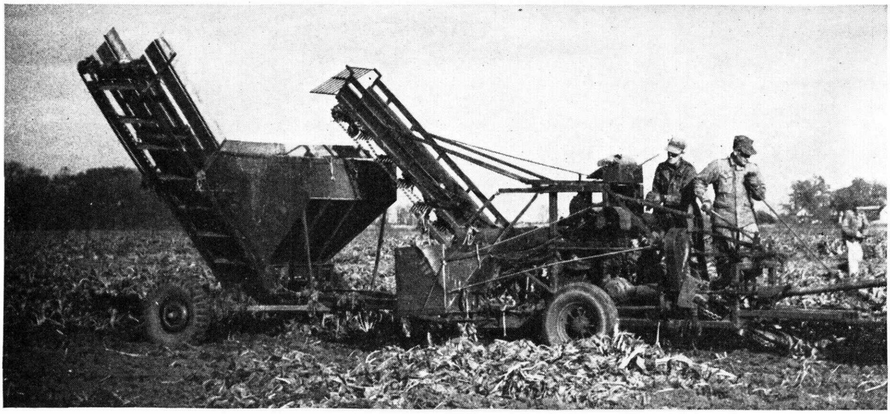

FIGURE 30.—Sugar beet harvester. With this type, the sugar beets are lifted, topped, and deposited in a trailer, which can elevate the roots into a truck.

Delivery of the Crop

Formerly when horse-drawn implements were used in harvesting the sugar beet crop and the pulling and topping were done by hand, the crop was also delivered to the weigh station by horse-drawn equipment. In those times the delivery of the crop was often delayed until all the beets had been harvested, the roots being piled in the fields and covered with the beet tops to prevent shrinkage. Delivery to the factory before the advent of cold weather was much slower, and the beets could be processed almost as fast as delivered. With the increasing use of the truck for beet hauling, delivery of the crop has become more rapid so that now the crop is delivered almost as fast as harvested and more rapidly than the beets can be processed. This has resulted in many of the beets being placed in storage piles at the factory (fig. 31). Although the grower benefited by the more rapid delivery of the crop, losses caused by heating and spoilage of the beets in the storage piles became a serious problem to the processor. At the present time, in order that the beets may be received and stored as rapidly as harvested with a minimum danger of loss from spoilage, many of the beet-sugar factories have installed equipment for ventilating and cooling the piles of stored beets until such time as they may be processed.

Diseases [2]

Cercospora Leaf Spot

Cercospora leaf spot of sugar beets is characterized by small circular spots, approximately one-eighth inch in diameter, on the leaf blades (fig. 32). Leafstalks are also attacked. Under severe attacks by the fungus, the spots run

[2] Prepared by G. H. Coons, principal pathologist, and Dewey Stewart, senior agronomist, Field Crops Research. The scientific names of the fungi causing the diseases are given on p. 42.

FIGURE 31.—Sugar beets being piled at the beet-sugar factory.

together; severely affected leaves dry and turn brown. The attack may be so severe that the entire field looks as if scorched by fire. The disease in this stage is commonly referred to as blight (fig. 33). The disease starts on the older leaves and advances to the younger leaves. Under conditions that favor disease outbreaks, a field may show a succession of blighting, apparent recovery, and another wave of blighting, and so on, until cool weather in the fall checks the disease.

The fungus that causes leaf spot is present on the seed; it also lives over the winter on trash and debris from a previous beet crop. Although severe blighting may not occur every season and the farmer may not notice leaf spot in his sugar beet field, the disease is present to some extent every year.

Climatic conditions determine the severity of the disease unless leaf-spot-resistant varieties of beets are planted. Rainy periods, spaced a week or two apart, and high temperatures in the first half of the growing season allow the fungus to increase rapidly. It is checked by cool spring or summer conditions.

Where wholesale blighting of the leaves occurs early, both root weight and sugar storage are lowered. Late attacks that come after the root growth is largely made sharply decrease sugar storage.

Leaf spot can be controlled by a rotation system in which sugar beets do not follow sugar beets. In general, an interval of more than 3 years should come between sugar beet crops. This rotation system should be followed even though leaf-spot-resistant

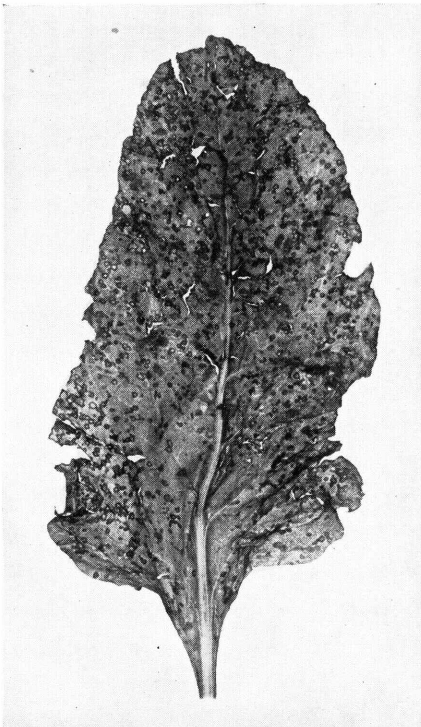

FIGURE 32.—Effect of leaf spot on sugar beet.

varieties are planted. Seed treatment is undoubtedly of benefit but does not control the disease.

Recently, leaf-spot-resistant varieties of beets have been developed. U. S. 215 × 216/3 has largely been used in the humid area. It is gradually being replaced by U. S. 216 MS × 226, a hybrid variety that is highly leaf-spot-resistant. It has a greater root yield than varieties introduced earlier. The hybrids are not immune to leaf spot. Some spotting of the leaves will occur, but they do not show the excessive burning and foliage destruction of susceptible varieties. In productivity they compare favorably with old varieties, and under leaf spot conditions the resistant hybrids produce 10 to 15 percent more sugar per acre. The breeding work is still going on, so that it may be expected that introduction of improved varieties will continue.

Black Root

Seedling diseases that reduce or even totally destroy stands of young sugar beet plants as they emerge from the soil, are called by farmers damping-off, or, more commonly, black root (fig. 34). The disease takes on two forms—acute and chronic. In the acute attacks, the seedlings are killed during germination or in a week or two after their emergence from the soil. This is the common cause of poor stands.

Often sugar beet seedlings are not killed within a week or two after emergence, but do not grow thriftily. On examination it will be found that all or nearly all of the lateral roots and the terminal part of the taproot are killed and blackened. The young plant is not able to establish and maintain proper root development to absorb food and water from the soil. This type of black root may persist throughout the life of the plant, and is called the chronic form. The leaves of young plants affected with the

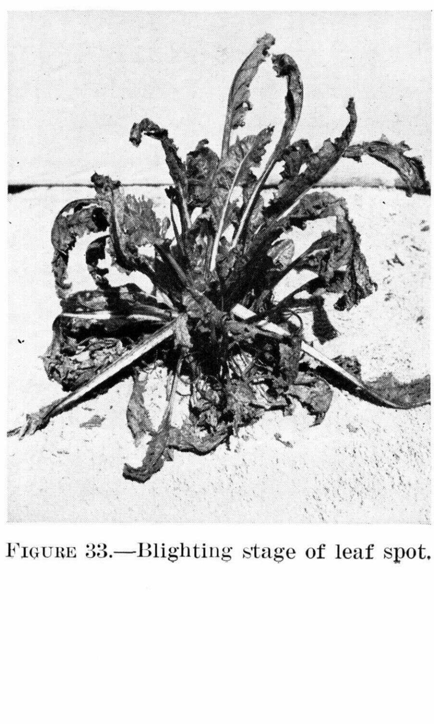

FIGURE 33.—Blighting stage of leaf spot.

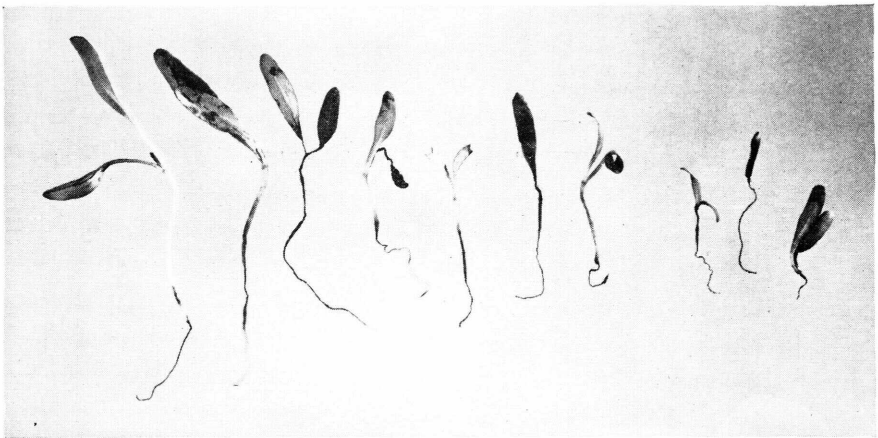

FIGURE 34.—Damping-off of sugar beet seedlings (black root).

chronic form of black root may become mottled, simulating a mosaic. Affected plants remain dwarfed and stunted and seldom reach marketable size.

Black root is especially severe in the humid area. If weather conditions are wetter than normal, stands of sugar beets may be extremely irregular. The fungi causing black root may have attacked the emerging sprouts and killed them. If some plants do emerge, many die within 2 or 3 weeks if weather conditions continue favorable for black root development. Other plants may persist but they are subject to the chronic form of the disease.

Effective control of the acute form of black root is dependent upon several practices. Alfalfa, sweetclover, red clover, and other leguminous crops are also subject to black root. If sugar beets follow a legume in the rotation, the legume should be plowed under in early fall in order to exhaust the food supply of the fungi causing black root and thus reduce their prevalence by the time the sugar beets are planted in the spring. The sugar beet crop should be grown on fields of high fertility that have good surface drainage. Fertilizer, especially phosphate, serves not only to increase beet yields by improving plant nutrition, but increases the resistance of the sugar beet crop to the black root fungi. One organism that causes black root is seedborne. Other species occur naturally in the soil. Seed treatment checks the seed-borne fungus and protects the young plant from the black root fungi in the soil. Arasan, Phygon, and other nonmetallic fungicides are generally used for seed treatment. As soon as rows can be followed in the field, a cultivation should be given to assist in soil aeration. Black-root-resistant varieties of sugar beets are being developed. These are very effective against the chronic form of the disease.

Rhizoctonia Root Rot

Although the sugar beet is subject to many types of root rot, rhizoctonia root rot has caused the most serious damage in the humid area. This rot commonly shows up fairly late in the summer and usually takes the form of a crown rot. Clefts appear in the root at or near the crown (fig. 35). The disease is first noted in the field by the presence of occasional plants with older leaves that are dying. Wilting and death of the younger leaves follow this

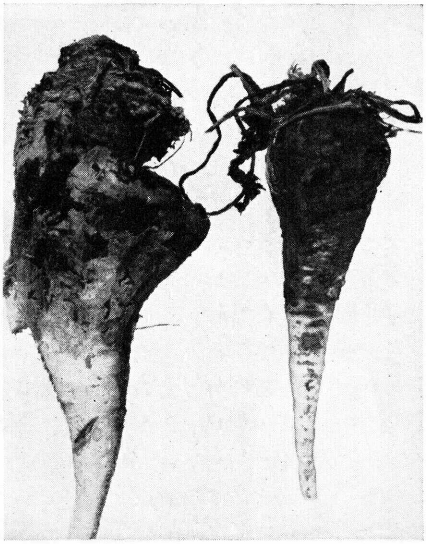

FIGURE 35.—Rhizoctonia crown rot of sugar beet.

stage. Roots of affected plants are found to be partially or completely decayed, the tissue being blackish brown. Rather coarse brown threads of the fungus can be seen on the roots, often filling the clefts as a weblike brown skein.

Several plants adjacent to each other in the row may show rhizoctonia root rot. After killing the root of a plant, the fungus invades the lower leaves and moves from these to the lower leaves of a neighboring plant, thus spreading along the row.

Such preventive measures as crop rotation in which the sugar beets follow corn or other nonsusceptible crop, good soil drainage, proper fertilization, and prompt cultivation are the chief means used to control the disease.

Insects and Their Control[3]

Although several species of insects are known to feed upon the foliage or roots of the sugar beet in the humid area of Michigan, Ohio, Indiana, Wisconsin, Minnesota, Iowa, Illinois, North Dakota, and eastern Nebraska, none of them ordinarily cause widespread damage. Certain insects, however, occasionally cause local damage in some fields or parts of fields, while adjacent or nearby fields may show little or no injury. The more important of the insects attacking sugar beets in the humid area are cutworms, flea beetles, webworms, armyworms, grasshoppers, white grubs, wireworms, aphids, and the spinach leaf miner.[4]

Cutworms

Cutworms cut off the stems of sugar beet plants near the soil surface. They feed mostly at night, and in the daytime rest in a curled-up position just below the ground. The first evidence of injury is the freshly cut wilted tops of the beets.

Fat, greasy-looking cutworms vary in color from gray to almost black and are $1\frac{1}{2}$ to 2 inches long when full grown. The back and sides may have stripes or other markings. The more important species attacking sugar beets in the humid area are the black cutworm, the glassy cutworm, the spotted cutworm (fig. 36), and the variegated cutworm. The glassy cut-

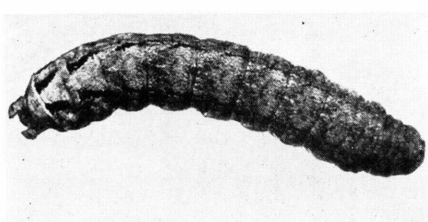

FIGURE 36.—The spotted cutworm. Nearly twice natural size.

[3] This section was prepared by D. J. Caffrey, entomologist, Entomology Research Branch.

[4] The scientific names of the insects that attack sugar beets in the North Central States are given on p. 42.

worm feeds underground, whereas the others feed principally near the soil surface. One should keep these habits in mind when applying control measures.

Control.—Most cutworms may be controlled by applying 10 percent toxaphene dust at 30 pounds per acre to the soil surface. The toxaphene may also be applied at 2 pounds per acre in a spray. If you have cutworms that do not come to the soil surface at night to feed, apply the toxaphene before planting and harrow it into the top inch of soil. The glassy cutworm has been controlled by working 5 percent DDT dust into the soil before planting, at the rate of 40 pounds per acre, then harrowing the top inch of soil.

Poison bait is also effective against most surface-feeding cutworms. Prepare the bait by mixing 1 pound of either sodium fluosilicate or paris green with 25 pounds of dry wheat bran and moistening with about 3 gallons of water. The wet or dry toxaphene baits recommended for grasshopper control (see p. 38) are also effective. Broadcast the bait evenly and thinly over the infested area at 15 to 20 pounds per acre late in the afternoon. Some of the cutworms may be killed the first night, but it usually takes 2 or 3 nights to kill most of them. Repeat the application if necessary.

Flea Beetles

Flea beetles are dark brown or black insects, ranging from about one-sixteenth to slightly less than one-fourth of an inch long, sometimes with stripes or bands on their backs. They eat tiny holes in the beet leaves and jump like fleas when approached. When they move into the beet fields in large numbers, they often cause severe damage to beets in the seedling stage and under some conditions may destroy an entire stand in 3 or 4 days. The striped flea beetle (fig. 37), the hop flea beetle, the spinach flea beetle, and the potato flea beetle are the most common kinds on sugar beets.

Control.—Apply 5 percent DDT dust at 20 pounds per acre as soon as the beetles are seen on the plants.

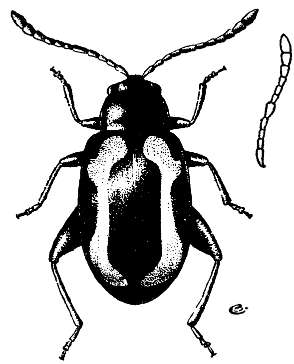

FIGURE 37.—The striped flea beetle. About 15 times natural size.

Webworms

Young larvae of the beet webworm (fig. 38) and the garden webworm eat small patches from the underside of sugar beet leaves. As they grow they destroy practically all the foliage and may feed on the stems and crowns of the plants. Webworms develop so rapidly that they may cause severe injury before growers are aware that they are present.

The moths of these webworms lay eggs on the underside of the beet leaves. The tiny eggs, which may be yellow, white, or green, are usually found in lines or clusters.

The larvae of these webworms are yellow to green caterpillars, about 1 inch long, with a black stripe and numerous black spots on

FIGURE 38.—The beet webworm. Twice natural size.

the back. They breed upon many kinds of weeds found in or near beetfields, especially lambsquarters and red-root pigweed.

Control.—Destroy all weeds upon which the webworms breed. Inspect beetfields often and apply a toxaphene spray or dust as soon as the eggs begin to hatch. Use 1½ pounds of technical toxaphene per acre in a spray or 25 to 30 pounds of 10 percent toxaphene dust. Parathion is also effective in a mist spray applied at ¼ pound per acre. Be sure to cover all parts of the foliage with the insecticide, directing particular attention to the underside of the leaves where the young webworms feed. Use three nozzles per row, one on each side and one above the row. Turn the side nozzles upward at a 45° angle. A canvas hood or trailer will keep the dust from drifting away.

Armyworms

Several species of thick-bodied caterpillars called armyworms sometimes move into beetfields in large numbers, usually at night. Occasionally they cause serious injury by eating the leaves and, at times, the roots of the plants. The beet armyworm and the yellow-striped armyworm (fig. 39) are often responsible for this type of damage.

Control.—The methods recommended for surface-feeding cutworms will control armyworms. Large numbers on the march may be trapped and destroyed by plowing a furrow around the field with a turnplow, throwing the soil away from the field. Apply 10 percent DDT or 20 percent toxaphene dust to the bottom of the furrow.

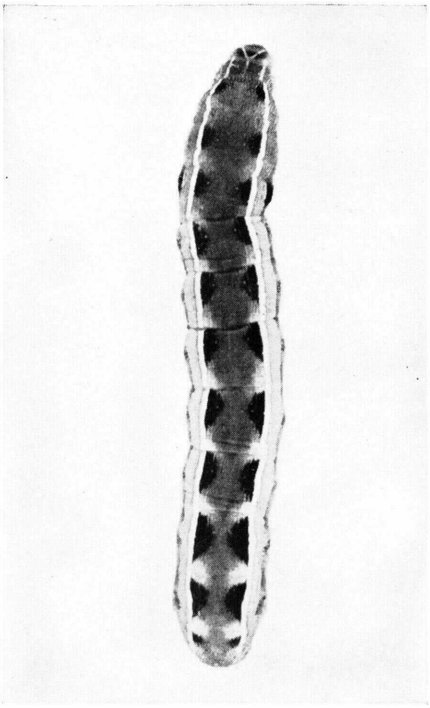

FIGURE 39.—The yellow-striped armyworm. Twice natural size.

Grasshoppers

Grasshoppers periodically cause great damage to the sugar beet crop. By devouring the leaves and feeding on the crowns, they prevent the growth of new leaves and thus kill the plants. The species most responsible for such damage are the two-striped grasshopper (fig. 40), the differential grasshopper, and the lesser migratory grasshopper.

Control.—To control young grasshoppers apply a spray containing toxaphene at the rate of 1½ pounds per acre as soon as your fields become infested. To kill

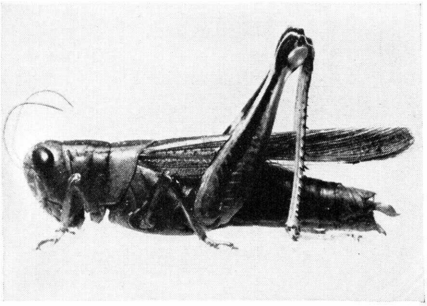

FIGURE 40.—Adult of the two-striped grasshopper. Two times natural size.

mature grasshoppers it may be necessary to increase the dosage slightly. Toxaphene may also be applied in bran baits.

White Grubs

In certain areas during some seasons sugar beets are damaged by white grubs, which are the larvae of May beetles. A full-grown white grub (fig. 41) is dirty-white with a brown or black head, usually found curled up, but 2 inches or more long when extended. These grubs never appear aboveground, but feed on the taproot and fibrous roots of small plants and also eat large holes in the sides of the beets. If the injury is severe, particularly to small plants, the leaves wither and die.

Control.—Since May beetles prefer grass and pasture lands for egg laying and grub development, do not plant these lands to sugar beets the first season they are plowed unless they are free of white grubs. Some species can be controlled by treating the soil with parathion and immediately harrowing the insecticide into the top 3 inches of soil. Use a 1-percent dust at the rate of 20 pounds per acre, or a spray at the same dosage of parathion.

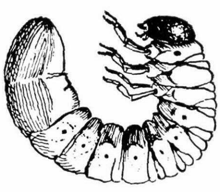

FIGURE 41.—White grub. About natural size.

Wireworms

Several kinds of wireworms, including the eastern field wireworm and the corn wireworms (fig. 42), sometimes injure small sugar beet plants. These jointed white to yellowish worms feed on the taproots just below the soil surface and often cut them off. Such injury causes the leaves to wilt and may stunt or even kill the plants. The kinds of wireworms that are found in the humid beet-growing areas favor grasslands and pastures, and one species inhabits lands that are poorly drained.

FIGURE 42.—One of the corn wireworms. Twice natural size.

Control.—Wireworms are difficult to control, but some damage may be prevented by growing an intertilled crop the first season after the plowing of wireworm-infested grasslands or pastures. Low, wet, or sour fields intended for growing sugar beets should be drained, if possible, as the wireworms that inhabit such soils do not thrive in well-drained land.

Wireworms may be destroyed by fumigating with ethylene dibromide. This fumigant is on the market as an 83-percent solution. Dilute to 40-percent strength by mixing 3 gallons with 7 gallons of kerosene or petroleum thinner. Apply this 40-percent solution at 10 gallons per acre. Use a special tractor-drawn machine or apply by gravity from a tank attached to the plow. For best results the temperature should be above 40° F. and the soil in good working condition and free of large clods or plant refuse.

Place the fumigant 6 inches deep in the soil at 12-inch spacings and cover immediately; then mulch the soil by shallow but thorough cultivation. Do not plant sugar beets for at least 2 weeks after applying ethylene dibromide.

Aphids

The bean aphid, which is black, and the green peach aphid sometimes infest sugar beets. They pierce the leaves of sugar beets and suck out the juices. Large colonies of these aphids retard growth and cause the leaves to become puckered and curl downward.

Control.—A dust or spray containing nicotine sulfate, parathion, or TEPP will control aphids on sugar beet foliage. Use a 4-percent nicotine sulfate or a 1-percent parathion or TEPP dust at the rate of 20 pounds per acre. If a spray is preferred, apply 1 pint of nicotine sulfate (40 percent) or ¼ pound of either parathion or TEPP per acre in 100 gallons of water. For scattered infestations spot treatments may be sufficient.

Spinach Leaf Miner

Spinach leaf miners are often found on sugar beet plants. The tiny white or yellowish maggots feed between the upper and lower surfaces of the leaves to form large, irregular-shaped mines, or blotches. Infested leaves usually turn brown and die prematurely. Loss of foliage from heavy infestations may retard the growth of the plant and reduce the yield, but ordinarily this insect does not cause serious loss.

Control.—Dusting or spraying with parathion or toxaphene when the insects first appear will give partial control of these leaf miners. Use 1-percent parathion or 10-percent toxaphene dust at the rate of 20 pounds per acre, or enough spray to give one-fourth pound of parathion or 1½ pounds of toxaphene per acre.

Precautions in Handling Insecticides

The insecticides recommended here are poisons. Handle them with care. Store them in closed containers in a place where they cannot be mistaken for food or medicine and where children or farm animals cannot reach them. See that these containers are properly labeled.

Parathion and TEPP are extremely dangerous poisons. They should be used only by trained operators who are thoroughly familiar with the hazards involved and who will assume full responsibility and enforce proper precautions.

When mixing insecticides wear gloves to protect your hands, and if the dust or fumes fill the air wear a mask or goggles. Take special care with ethylene dibromide and nicotine sulfate, for they give off toxic vapors. Ethylene dibromide will burn the skin. Toxaphene may be absorbed through the skin. Always wash your hands and face with soap and water after handling insecticides. Also wash all utensils and tools as soon as you have finished mixing.

DDT and toxaphene leave a poisonous residue on the foliage. Do not feed sugar beet tops treated with these materials to milk animals or to meat animals being finished for slaughter.

Byproducts

The sugar beet tops and crowns are a byproduct of the sugar beet crop. Waste lime or lime cake, molasses, and beet pulp are byproducts of the factory processes. All these byproducts have agricultural value.

Although the beet tops and crowns have a very definite and con-

siderable value as a source of organic matter for the soil and as a fertilizer for the following crop, they have even greater value as feed for livestock. An efficient practice is to conserve the tops and feed the stock on the farm so that the manure will be available for fertilizing the fields. The green weight of the tops and crowns produced in a field may almost equal the weight of the roots produced. If the latter part of the summer and the harvesting season are dry, the ratio of tops to roots may be as little as 1 to 4; usually top weight is at least half that of the roots. In the humid area, the fullest and most economical use of the tops and crowns is not generally made. Farmers find it much easier to pasture the tops in the field than to make and feed the silage.

Formerly when the beets were topped by hand, saving the beet tops was relatively easy, as the toppers left them in windrows or piles from which they could be gathered and hauled to the silo or fed upon by cattle and sheep. In their early stage of development, some mechanical harvesters were not equipped with devices to place the tops after they were cut from the roots so that they were not run over by the machine itself or by trucks hauling the beet roots from the field. In order that the best use may be made of the tops and crowns, all harvesting machines should be equipped with devices to save the tops and crowns in a clean condition.

In processing the sugar beets, the roots are sliced into cossettes and the sugar extracted. The extracted cossettes are known as beet pulp. Fresh or wet beet pulp is heavy and bulky, but in some sections of the country it is hauled from the factory and fed to cattle. In the humid area practically all of the beet pulp produced is dried and sold to manufacturers of proprietary feeds.

In the process of beet-sugar refining, limestone is employed to the extent of approximately 6 percent of the weight of the roots sliced. The spent lime is finally discharged into settling basins near the factory. It is later removed and piled (fig. 43). Although the waste lime con-

FIGURE 43.—Loading waste lime from a pile at a beet-sugar factory.

tains some of the mineral plant food elements in small amounts, its chief value in agriculture is as lime. This supply of lime cake, factory lime, or waste lime, as it is variously called, is highly important in meeting the soil-liming problem. Since factory lime is readily available, the maintenance of the farm soil at optimum reaction can be accomplished economically. Full advantage of this source of lime should be taken by every sugar beet grower.

The residue from the sugar refining processes, consisting of uncrystallizable sugar and various mineral constituents, is called beet molasses. It has a high feed value and should be utilized for feeding cattle and other livestock. Some is used in making molasses silage, some is fed direct by spreading it upon dry roughage in mangers, and some is used in the manufacture of proprietary feeds. At the present time in the humid area, however, the greater portion is used as raw material for yeast production.

Properly used, sugar beet byproducts can bring high returns to the farmer, making the sugar beet crop still more profitable and aiding greatly in the maintenance of soil fertility.

Scientific Names of Causal Organisms

Disease	*Causal organism*
Cercospora leaf spot	*Cercospora beticola.*
Black root:	
Acute form	*Pythium* spp. *Phoma betae.* *Pellicularia filamentosa.*
Chronic form	*Aphanomyces cochlioides.*
Rhizoctonia root rot	*Pellicularia filamentosa.*

Scientific Names of Insects

Insect	*Scientific name*
Aphids:	
Bean	*Aphis fabae.*
Green peach	*Myzus persicae.*
Armyworms:	
Beet	*Laphygma exigua.*
Yellow-striped	*Prodenia ornithogalli.*
Cutworms:	
Black	*Agrotis ypsilon.*
Glassy	*Crymodes devastator.*
Spotted	*Amathes c-nigrum.*
Variegated	*Peridroma margaritosa.*
Flea beetles:	
Banded	*Systena taeniata.*
Hop	*Psylliodes punctulata.*
Potato	*Epitrix cucumeris.*
Spinach	*Disonycha xanthomelas.*
Striped	*Phyllotreta striolata.*
Grasshoppers:	
Differential	*Melanoplus differentialis.*
Lesser migratory	*Melanoplus mexicanus mexicanus.*
Two-striped	*Melanoplus bivittatus.*
Spinach leaf miner	*Pegomya hyoscyami.*
Webworms:	
Beet	*Loxostege sticticalis.*
Garden	*Loxostege similalis.*
White grubs	*Phyllophaga* spp.
Wireworms:	
Eastern field	*Limonius agonus.*
Corn	*Melanotus* spp.

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